TITLE PAGE

Associations with wellbeing and medication adherence in young adults receiving kidney replacement therapy

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ABSTRACT

BACKGROUND AND OBJECTIVES: Young adults receiving kidney replacement therapy have impaired quality of life and may exhibit low medication adherence. We tested the hypothesis that wellbeing and medication adherence are associated with psychosocial factors.

DESIGN, SETTING, PARTICIPANTS AND MEASUREMENTS: We conducted a cross-sectional online survey for young adults on KRT. Additional clinical information was obtained from the United Kingdom Renal Registry. We compared outcomes by treatment modality using age and sex adjusted regression models, having applied survey weights to account for response bias by gender, ethnicity and socio-economic status. We used multivariable linear regression to examine psychosocial associations with scores on the Warwick-Edinburgh Mental Wellbeing Scale and the 8-item Morisky Medication Adherence Scale.

RESULTS: We recruited 976 young adults and 64% responded to the survey - 417 (71%) with transplants and 173 (29%) on dialysis. Wellbeing was positively associated with extraversion, openness, independence, and social support, and negatively associated with neuroticism, negative body image, stigma, psychological morbidity, and dialysis. Higher medication adherence was associated with living with parents, conscientiousness, physician access satisfaction, patient activation, age, and male sex, and lower adherence with comorbidity, dialysis, education, ethnicity and psychological morbidity.

CONCLUSIONS: Wellbeing and medication adherence were both associated with psychological morbidity in young adults. Dialysis treatment is associated with poorer wellbeing and medication adherence.

KEYWORDS

Mental health, quality of life, wellbeing, medication adherence

INTRODUCTION

End-stage kidney disease affects the psychosocial health of young adults aged 16-30 years receiving kidney replacement therapy (KRT). A recent systematic review demonstrated lower quality of life (QOL) compared to the general population, particularly for patients on dialysis(1, 2). We have previously reported that young adults on KRT have lower mental wellbeing and were twice as likely to have psychological morbidity (defined by a 12-item General Health Questionnaire (GHQ-12) score ≥4) compared to the age and sex matched general population, again more pronounced for patients on dialysis(2). However, the determinants of wellbeing have not been established in this population. A qualitative synthesis exploring young adults' perspectives on living with kidney failure described overall themes of uncertainty and liminality, difference and the desire for normality, and thwarted or moderated dreams and ambitions. Key underlying themes included physical appearance/body image and social isolation(3).

The Society for Adolescent Health and Medicine's position statement on young adults' health and wellbeing says "Young adulthood is a unique and critical time of development where unmet health needs and health disparities are high. Purposeful prevention and intervention strategies should be developed, researched, and implemented during this time to improve health and wellbeing of young adults"(4). Needing KRT during young adulthood may have lasting consequences for later life. Medication non-adherence is common amongst kidney transplanted adolescents, estimated at 43% in a systematic review(5). Adults with chronic kidney disease (CKD) and poor adherence are more likely to have progressive disease(6), graft loss and death(7). Young adults are the highest risk age-group for kidney transplant loss(8, 9). Medication non-adherence was estimated to account for 32% of kidney transplant loss in this group(5). Psychosocial wellbeing is a priority for patients and may provide insights into perceived poor engagement with healthcare services and medication adherence.

We have tested the hypothesis that wellbeing and medication adherence are associated with psychosocial factors using data from the 'SPEAK' (Surveying Patients Experiencing young Adult Kidney failure) study, a national cross-sectional survey of UK 16 to 30-year olds receiving KRT. We aimed to establish protective and risk factors to aid identification of high-risk sub-groups and potential interventions.

MATERIALS AND METHODS

We designed a cross-sectional online self-completion survey for 16 to 30-year olds receiving KRT in the UK, after an initial pilot. The survey comprised questions (in English) from validated health surveys (reported elsewhere(2)) with comparable normative data. Additional scales and tools covering aspects of chronic disease were also included (described in supplementary table 1). The study was granted ethical approval by the Health Research Authority National Research Ethics Service Committee, reference 15/SW/0101.

Clinical subjects

The study inclusion criteria were 1) aged ≥16 years and <31 years and 2) receiving maintenance KRT. We chose a wide age range as there is no consensus definition of young adulthood. Subjects were excluded if participation was expected to cause psychological distress or they were unable to complete the questionnaire with assistance. Subjects were identified and approached for participation by the hospital providing their KRT. All National Health Service trusts with an adult or pediatric kidney unit (n=74) took part in the study, yet two did not recruit any participants. Sites opened sequentially and recruited for six months, between 2015 and 2017. We aimed to recruit 1000 young adults and estimated a 50% response rate. Assuming equal group sizes, this provided 90% power to detect a standardized difference (z-score) of 0.29 (α=0.05) and a 10% proportion difference for an outcome with a 10-50% prevalence.

Participants selected survey access by email, or via a computer at their kidney unit (where available). Participants could be supported in survey completion as required. If no survey response was received, e-mail reminders were sent at 7 days, and at 14 days the kidney unit checked survey receipt and provided another reminder. We requested screening logs from sites to assess reasons for study non-participation.

Survey software

Study data were collected and managed using Research Electronic Data Capture (REDCap) hosted at the University of Bristol(10). REDCap is a secure, web-based application designed to support data capture for research studies. It provided greater convenience to our participants than a paper survey by allowing a 'save and return' option and through use of branching logic to deliver relevant questions based on preceding filter responses, thereby reducing the burden of survey completion. Further, it avoided printing, postage and data entry costs and potentially reduced the risk of introducing data entry errors.

Clinical data from the UK Renal Registry (UKRR)

The UKRR collects data on all KRT patients from UK adult and pediatric kidney units(11, 12). It has been granted a section 251 exemption by the Health Research Authority, allowing the registration of identifiable patient information from kidney units without first asking individual patient consent. All participants were asked for consent to access their UKRR data regardless of survey response. We also accessed anonymized aggregate level data for study non-participants (those eligible for the SPEAK study as of December 2015, but who did not give consent), to enable comparison to the wider young adult population. This allowed examination and adjustment for response bias and description of clinical aspects for young adults receiving KRT. We classified primary kidney disease using a recent European coding system(13).

Survey response

We weighted survey responses as the inverse of the sampling fraction for gender, ethnicity and socio-economic deprivation, to account for survey response bias and thus be representative of the wider young adult KRT population.

Statistical analysis

We compared scale results by clinical characteristics (sex, treatment modality, pediatric/adult starting unit and duration) using age and sex adjusted regression models, appropriate to the data

and distribution. We followed scale author recommendation or published methods for handling missing data, using average or lowest score substitution. We developed theoretical frameworks to examine associations of selected outcomes. We used the Wilson and Cleary QOL model adapted by Ferrans et al(14) (supplementary figure 1), because this includes additional dimensions to explain QOL better(15). We chose the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) as the outcome variable in this model over EQ-5D-3L as it is less driven by physical aspects. For medication adherence, we used the 8-item Morisky Medication Adherence Scale (MMAS-8) and devised our own framework (supplementary figure 2) as we could find no precedent in the literature. In each framework we examined the explanatory variables (shaded variables in supplementary figures 1 and 2) in turn to establish whether they were associated in an age and sex adjusted regression model. We combined shortlisted variables in a multivariable linear (least squares) regression model, adjusting for confounders. We removed non-associated explanatory variables from the final model, having checked that this did not affect the beta coefficients of the remaining variables. We checked for assumptions of linearity between continuous variables and the outcome variable, evidence of heteroscedasticity and that residuals were normally distributed with a mean of zero. We also tested for potential pre-specified interactions in our theoretical frameworks. We used Stata® 14 for our analyses.

RESULTS

Survey response

Figure 1 displays a study flowchart. Overall, 976 participants were recruited. The main reasons for study non-participation (data available from 48 sites) were 1) no response to the invitation letter (14%); 2) participation declined (9%) and 3) the subject could not be contacted (6%). The survey response rate was 64% (625/976) and has been described previously(2). There were 2,072 young adults known to the UKRR who did not participate, so our sample comprises 21% of the total eligible population. Characteristics of responders are shown in table 1. Responders were statistically more likely to be female, Caucasian, and have higher socio-economic status, compared to both survey non-responders and study non-participants. Compared to both survey non-responders and study non-participants, survey responders were more likely to be managed in smaller centers that do not undertake kidney transplantation. Survey responders with transplants had a slightly lower estimated glomerular filtration rate (eGFR) (-3.2 mls/min/1.73m^2, 95% confidence interval (CI) -5.9, -0.5, p=0.02) than non-responders and non-participants, although this is of uncertain significance. There were no other differences. The median time to complete the survey was 53 minutes (interquartile range 40, 71) and most (595/625, 95%) selected survey access by email.

Cohort characteristics

The cohort comprised 417 (71%) patients with transplants and 173 (29%) on dialysis, and has been previously described(2). Survey participants were 51% male, 74% Caucasian, with a median age of 25 years. The most common primary kidney disease group was 'tubulointerstitial diseases' (31%) due to structural causes, followed by 'glomerular diseases' (27%). The median duration since KRT start was 6 years. The majority (59%) started KRT in adult services. Most were transplanted (71%), and the mean eGFR was 59 mls/min/1.73m^2 (standard deviation (SD) 23). Few young adults were using peritoneal dialysis (6%, compared to 24% using hemodialysis). A fifth started KRT <90 days from first

nephrology review. Around 80% had undergone transplantation, with 27% having experienced transplant failure.

Quality of Life, wellbeing, psychological morbidity, medication adherence and other scales

Average scale scores are shown in table 2 (higher scores indicate better outcome unless stated below). The median EQ-5D tariff was 0.80 (interquartile range (IQR) 0.62, 1.00; possible range -0.59, 1.00). From the GHQ-12, overall 43% had no evidence of mental health problems, 26% had below optimal mental health and 31% had probable psychological disturbance/mental ill health. The median Independence with Activities of Daily Living score was 26 (IQR 21, 27; possible range 9, 27). Medication adherence was low in 43%, medium in 34% and high in 23%. The median Body Image Scale score was 9 (IQR 3, 18; possible range 0, 30 - higher scores indicate worse body image). The median Social Impact Scale score was 40 (IQR 28, 53; possible range 21, 90 - higher scores indicate greater stigma). The median Multidimensional Scale of Perceived Social Support scale score was 65 (IQR 54, 75; possible range 12, 84). On average, patient satisfaction was scored as 4 (possible range 1, 5) across seven domains. The mean wellbeing score was 47.4 (SD 11.5; possible range 14, 70). There was good illness acceptance in 34%, moderate acceptance in 49%, and no acceptance in 17%. Patient activation was level 1 (may not yet believe that the patient role is important) in 26%, level 2 (lacks confidence and knowledge to take action) in 18%, level 3 (beginning to take action) in 36% and level 4 (has difficulty maintaining behaviors over time) in 20%.

Scale results by treatment modality

Compared to transplant, young adults on dialysis had lower QOL (OR for EQ-5D 'No problems' 0.31; 95% CI 0.19, 0.51; p<0.001), wellbeing (β -5.61; 95% CI -7.92, -3.29; p<0.001), disease acceptance (β -5.35; 95% CI -6.78, -3.91; p<0.001) and patient activation (β -4.52; 95% CI -6.94, -2.10; p<0.001) (table 3). They were more likely to have worse psychological health (GHQ-12 group odds ratio (OR) 1.9; 95% CI 1.2, 3.0; p=0.005), body image (above median score OR 1.7; 95% CI 1.1, 2.8; p=0.02), independence (below median score OR 0.3; 95% CI 0.2, 0.5; p<0.001) and stigma (above median

score OR 2.5; 95% CI 1.6, 3.9; p<0.001). Generally, young adults on dialysis were less satisfied, apart from 'Interpersonal Manner' and 'Financial Aspects' domains and these associations were unlikely to be due to chance. There was no difference in social support by treatment modality (OR 0.9; 95% CI 0.61, 1.34; p=0.6). Compared to transplant, young adults on dialysis had lower medication adherence (MMAS group OR 0.4; 95% CI 0.2, 0.6; p<0.001). Supplementary table 1 details further comparisons by gender, pediatric or adult starting unit and duration. There were few differences by start or duration although young adults who started KRT in childhood had higher disease acceptance and a slightly higher patient activation score.

Factors associated with wellbeing

The greatest association with lower wellbeing was psychological morbidity (β -7.1; 95% CI -8.8, -5.4; p<0.001) (figure 2). Dialysis was also associated with lower wellbeing (β -1.8; 95% CI -3.2, -0.3; p=0.02) though we observed an attenuated effect from the crude differences (table 3) after adjustment in the multivariable model. Other negative associations included neuroticism (β -2.8; 95% CI -3.9, -1.8; p<0.001), negative body image (β -1.3; 95% CI -2.4, -0.3; p=0.01) and stigma (β -2.1; 95% CI -3.3, -0.8; p=0.001). In contrast, positive associations with wellbeing were: extraversion (β 2.2; 95% CI 1.2, 3.2; p<0.001) or openness (β 1.9; 95% CI 0.7, 3.1; p=0.002), independence with activities of daily living (β 2.8; 95% CI 1.4, 4.3; p<0.001), and higher social support (β 2.5; 95% CI 1.0, 3.9; p=0.001). Gender (β -1.2; 95% CI -2.6, 0.2; p=0.1) and age group (p=0.6 for trend) did not affect wellbeing when adjusted for other factors. Our final wellbeing model had an adjusted R^2 value of 68% suggesting reasonable model fit. We found no evidence for interaction between: GHQ-12 score and neuroticism, dialysis treatment or Independence with activities of daily living score; social support and extraversion or neuroticism; dialysis treatment and employment status. Univariable coefficients are shown in supplementary table 3.

Factors associated with medication adherence

Factors lowering medication adherence (figure 3) comprised: having an additional condition (β -0.4; 95% CI -0.7, -0.1; p=0.02), a lower age of finishing full-time education (p=0.01 for trend), Black and Asian ethnicities (β -1.5; 95% CI -2.4, -0.6; p=0.002, β -0.7; 95% CI -1.2, -0.1; p=0.02 respectively) and psychological morbidity (β -0.7; 95% CI -1.1, -0.4; p<0.001). Dialysis was also negatively associated, and the association was lessened from the crude difference (β -1.1; 95% CI -1.5, -0.8; p<0.001) after adjustment in the multivariable model (β -0.6; 95% CI -0.7, -0.1; p<0.001).

In contrast, factors associated with a higher medication adherence score were: living with parents (β 0.4; 95% CI 0.1, 0.8; p=0.01), conscientiousness (β 0.7; 95% CI 0.4, 0.9; p<0.001), greater physician access satisfaction (β 0.3; 95% CI 0.1, 0.5; p=0.008), higher patient activation (p=0.008 for trend), male gender (β 0.3; 95% CI 0.02, 0.6; p=0.04) and being aged 16 to <21 years (β 0.5; 95% CI 0.02, 1.0; p=0.04). There was no change in the dialysis coefficient after adjustment for psychological morbidity and/or patient activation (data not shown), suggesting these do not mediate the dialysis treatment effect.

There was a significant interaction (likelihood ratio test p=0.002 between full model and model fitting the interaction term) between ethnicity and dialysis treatment. The stratum-specific exposure effects of ethnicity and dialysis (compared to White, dialysis) are as follows: Asian, Dialysis: β -1.19 (95% CI -2.21, -0.16), p=0.02; Black, Dialysis: β -2.82 (95% CI -4.02, -1.62), p<0.001; Mixed/Other, Dialysis: β 0.60 (95% CI -1.20, 2.40), p=0.5; White, Transplant: β 0.50 (95% CI 0.14, 0.86), p=0.006; Asian, Transplant: β 0.02 (95% CI -0.69, 0.73), p=0.96; Black, Transplant: β 0.83 (95% CI -0.58, 2.24), p=0.2; Mixed/Other, Transplant: β -0.12 (95% CI -1.20, 0.95), p=0.8. There was no interaction between: living with parents and age at finishing full-time education or dialysis treatment; patient activation and conscientiousness or age at finishing full-time education; dialysis treatment and GHQ-12 score. Univariable coefficients are shown in supplementary table 4.

DISCUSSION

In young adults on KRT, worse outcomes for mental wellbeing and medication adherence were both associated with psychological morbidity and dialysis treatment, whilst social support and living with parents were associated with better outcomes. These findings are important because psychological disturbances may be treatable and should prompt caregivers to evaluate psychological state carefully as well as barriers to transplantation. Further, there is large potential for health and healthcare improvements for young adults due to the longer life expectancy compared to older adults on KRT. Psychological problems may be under-recognized; using the GHQ-12 as a screening tool, 31% of young adults on KRT had psychological morbidity, but only 17% reported their condition affected their mental health(2). Therefore, opportunities to identify and improve mental health may be being missed. Although some associated variables may be non-modifiable, their potential measurement in clinical practice might help identify those at higher risk of poor outcomes for close monitoring, greater psychosocial support, or targeted intervention. Compared to transplant, dialysis was associated with reduced QOL, wellbeing, disease acceptance, independence with activities of daily living, medication adherence, patient activation and patient satisfaction and a higher likelihood of psychological disturbance, worse body image and stigma.

Our data furthers previous systematic evidence of lower QOL in young adults on dialysis compared to transplant(1) even after adjusting for a wide range of psychosocial variables, by identifying associated factors in a robust dataset. Our wellbeing model variables explained a high proportion of the variance. Young adults on dialysis have an increased mortality risk(16); our findings show dialysis is associated with lowered psychological as well as physical health. Our estimate of young adult low medication adherence mirrored that of adolescent non-adherence in a systematic review, at 43%(5). Although no clinical or psychosocial factors were associated with medication adherence in a previous study of transplanted young adults(17), we report many associations that are unlikely to be due to chance. Depression is known to lower adherence and be a major determinant of QOL in older

adults on KRT(18-20). Our study provides evidence that this is also true for young adults. Beliefs about medication were associated with adherence in a previous study of adults with kidney transplants(21); a similar effect may be seen in our data through conscientiousness and patient activation.

Although the proportion with psychological morbidity is similar to the overall meta-analytical prevalence of depression in older adults with CKD [34.0% (95% CI 31.9, 36.2)](22), psychosocial health during young adulthood may have lasting life-course influences on developing adult identity and other outcomes(23). We found similar associations of extraversion, neuroticism and openness with mental wellbeing in young adults on KRT as previous studies of older adults with CKD(24) and kidney transplants(20). We have previously shown that compared to the general population, young adults are three times more likely to live in the family home(2) and whilst diminished independence could be considered undesirable, it had a positive association in our medication adherence model.

Potential mechanisms underlying the psychosocial determinants of medication adherence include individual and environmental factors. Our data showed a lower age of finishing full-time education was associated with less adherence. This could be due to reduced health literacy. In a retrospective cohort study, half of young adults with CKD had limited health literacy skills, but health literacy was not associated with clinical outcomes(25). We found patient satisfaction was associated with higher adherence, suggesting that co-producing services with young adults could be valuable in engaging patients and improving healthcare utilization. Increasing patient activation was associated with higher adherence. In a longitudinal study, more activated patients were less likely to develop diabetes and diabetics were more likely to have better diabetic clinical indicators(26). Interventions that improve activation could have wider benefits than improving adherence alone.

A range of psychosocial interventions have promise in improving outcomes, personality traits and adherence in chronic conditions, but evidence is lacking in KRT populations. Self-affirmation has been shown to improve phosphate and fluid management in adult hemodialysis patients(27, 28). A

systematic review of personality traits changes through intervention found marked differences over 24 weeks in personality trait measures(29). Supportive evidence for interventions can also be found with other chronic conditions affecting young adults. There was modest evidence from a systematic review that psychological interventions improved glycemic control in children and adolescents with type 1 diabetes but not in adults(30). This suggests that we cannot assume interventions will be effective in young adults and require formal evaluations. Similarly, there is evidence from a systematic review that education, electronic trackers/reminders and simplified regimens result in better medication adherence amongst asthmatic patients than control interventions(31). Interventions can also positively influence social outcomes. Group cognitive behavioral therapy (CBT) has been shown to lower GHQ scores in the long-term unemployed, and compared to control programs increases the likelihood of finding full-time employment after 4 months(32). CBT could be a promising intervention in the improvement of wellbeing and medication adherence in young adults on KRT.

Our study is strengthened by providing a comprehensive evaluation of aspects of psychological health in young adults on KRT, through utilization of established and widely-used scales. It is the largest cohort of young adult transplant and dialysis patients, with variation in modality and age at presentation. The study was multicenter, and our survey had a similar response rate to a large previous study of young adults with kidney transplants(33). By linking our survey data to a national kidney registry, we enhanced our self-reported data with clinical data. We reduced survey response bias by weighting our data, thereby improving generalizability to the wider young adult KRT population.

Our study has several important limitations that need to be considered. The design is cross-sectional, meaning the impact of treatment changes on the outcomes cannot be tracked and directionality between any of the variables cannot be established. For example, dialysis decisions may be influenced by poor social support/treatment engagement, comorbidities and prognosis

rather than being the cause of the observed negative associations. Longitudinal studies are needed to help determine the sequencing of events. Some kidney units were able to provide tablet devices to facilitate survey access (especially during dialysis) but this was not consistent. Self-reported outcomes may be prone to bias. We had missing data both from non-responders and non-participants, though the use of anonymized UKRR allowed us to examine these differences. Although we adjusted for observed response bias, there may be residual unobserved bias due to limited comparisons with aggregate UKRR data for study non-participants. We did not conduct a mediation analysis, hence for those variables with potential mediators, total effects only were measured. We focused on medication adherence (an area of considerable interest for caregivers of young adults on KRT) although strong evidence that this is directly linked to graft loss is lacking. Our medication adherence model only explained a third of the observed variance in medication adherence scores. We found an interaction between dialysis and ethnicity so that Asian and Black patients on dialysis did worse in relation to medication adherence. This could relate to socio-cultural factors, but more work is required to understand these results. Pragmatically, it suggests these patients may require even greater clinical support.

Future studies should enhance the understanding of our findings. In summary, this study demonstrates potentially modifiable associations with the important outcomes of wellbeing and medication adherence in young adult on KRT. This evidence base should form the basis for future research aimed at improving clinical and QOL outcomes. As psychological morbidity had a strong association with wellbeing and medication adherence, multidimensional interventions improving psychological health should be developed to improve outcomes.

DISCLOSURES

None

SUPPLEMENTARY MATERIAL

Supplementary table 1. Summary of questionnaire scales.

Supplementary table 2. Psychological health in UK young adults receiving kidney replacement therapy, and regression analyses by gender, current treatment and starting unit.

Supplementary figure 1. Theoretical model of factors associated with quality of life in young adults receiving kidney replacement therapy.

Directly measured variables are shaded blue and domains are unshaded. There may be bidirectionality between variables.

Supplementary figure 2. Theoretical model of factors associated with medication adherence in young adults receiving kidney replacement therapy.

Directly measured variables are shaded green and domains are unshaded. There may be bidirectionality between variables.

Supplementary table 3. Coefficients and 95% confidence intervals for each variable in the wellbeing model in univariable analyses, for comparison to the mutually adjusted model shown in figure 2.

Supplementary table 4. Coefficients and 95% confidence intervals for each variable in the medication adherence model in univariable analyses, for comparison to the mutually adjusted model shown in figure 3.

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TABLE 1. Clinical characteristics of survey responders.

Variable	Survey responders (n=625)	
	n	Proportion (%)
Male sex	625	51
Age, years (median, IQR)	625	25 (21, 28)
Age group (16 to <21/21 to <26/26 to <31 years)	625	21, 30, 48
Country	625	
England		74
Scotland		6
Wales		10
Northern Ireland		10
Ethnicity	625	
White		85
Asian		9
Black		4
Other		3
Index of multiple deprivation quintile (1 - least deprived/2/3/4/5 - most deprived)[1]	625	19, 21, 17, 22, 21
Managed in adult centre & aged <20 years	101	57
Managed in transplant centre	625	55
Nephrology unit size (small/medium/large)[2]	625	18, 46, 35
Managed in Transition clinic centre[3]	625	64
UK Renal Registry linked	N=609	97%
Duration since KRT start, years (median, IQR)[4]	609	6 (2, 11)
Started in Adult unit	609	59
Primary kidney disease[5]	572	
Glomerular diseases		27
Systemic diseases affecting the kidney		7
Familial/hereditary nephropathies		11
Tubulointerstitial diseases		31
Miscellaneous kidney disorders		18
Time to KRT start from first nephrology review, days (median, IQR)	431	745 (40, 1984)
Time to KRT start for those in paediatric services	396	667 (34, 1923)
Time to KRT start for those in adult services	35	1048 (211, 3441)
Late referral (Time to KRT start <90 days/90 to <365 days/≥365 days)	431	21, 9, 41
Timeline data complete	N=590	97%
Starting modality	590	
Haemodialysis		37
Peritoneal dialysis		39
Transplant		21
Starting transplant type	125	
Live donor		46
Deceased donor		45
Unknown		9
Current modality	590	
Transplant		71
Haemodialysis		24
Peritoneal dialysis		6
Current transplant type	417	

Live donor			39
Deceased donor			52
Unknown			9
Modality changes >90 days (0/1/≥2)	590		31, 38, 28
Ever had a transplant	590		82
Ever had a failed transplant	502		27
Number of transplants (mean, SD)	502		1 (1)

Biochemical variables	Transplant (n=417)		Dialysis (n=173)	
	n	Mean (SD)	n	Mean (SD)
Estimated glomerular filtration rate, ml/min/1.73m^2	414	59 (23)	-	-
Chronic kidney disease stage (1/2/3a/3b/4/5) (Proportion, %)	414	10, 36, 26, 17, 7, 2	-	-
Haemoglobin, g/L	414	127 (18)	169	107 (17)
Ferritin, µg/l (median, IQR)	350	135 (54, 308)	168	351 (211, 608)
Bicarbonate, mmol/L	383	23 (3)	158	24 (4)
Calcium, mmol/L	413	2.40 (0.12)	171	2.30 (0.22)
Phosphate mmol/L	415	1.00 (0.26)	171	1.82 (0.64)
Parathyroid hormone, pmol/L (median, IQR)	326	8.1 (5.0, 13.0)	157	38.7 (18.5, 86.1)
Systolic blood pressure, mmHg	320	127 (14)	140	138 (25)
Diastolic blood pressure, mmHg	305	77 (11)	137	84 (18)
Weight, kg	303	68 (19)	137	71 (24)

IQR - interquartile range, SD - standard deviation, KRT - kidney replacement therapy

Participant interaction with the online survey that led to the generation of an identifiable survey record was counted as a response. Not all percentages may total 100 due to rounding. Where non-parametric, data are presented as median and interquartile range.

1. We used derived UK-wide indexes of multiple deprivation quintiles(34) using postcodes.
2. Defined by tertiles of prevalent KRT patients in 2015; we defined small units as having <500 adult patients/<50 paediatric patients, medium units as having 500 to <1500 adult patients/50 to <100 paediatric patients, and large units as having ≥1500 adult patients/≥100 paediatric patients.
3. As of September 2015(35), with additional data obtained directly from kidney units.
4. If KRT start date was missing, the first timeline entry date was substituted.
5. According to the 2012 European Renal Association-European Dialysis and Transplant Association coding system(13).

TABLE 2. Psychological health in UK young adults receiving kidney replacement therapy

Scale	Possible range	N	Weighted average score	Weighted measure of variability	Group	Weighted proportion (%)
			Median	**IQR**		
EQ-5D-3L tariff	-0.59, 1.00	538	0.80	0.62, 1.00		
General health questionnaire (GHQ-12)	0, 12	527	1	0, 5	Score 0 / 1-3 / ≥4	43, 26, 31
Independence with activities of daily living scale	9, 27	545	26	21, 27		
Morisky medication adherence scale (MMAS-8)[1]	0, 8	543	6.5	4.75, 7	Low / Medium / High	43, 34, 23
Body image scale	0, 30	520	9	3, 18		
Social impact scale	21, 96	467	40	28, 53		
Multidimensional scale of perceived social support	12, 84	499	65	54, 75		
Patient satisfaction questionnaire (PSQ-18)						
General Satisfaction	1, 5	500	4	3, 4.5		
Technical Quality	1, 5	499	4	3.5, 4.5		
Interpersonal Manner	1, 5	502	4	3.5, 5		
Communication	1, 5	503	4	3.5, 4.5		
Financial aspects	1, 5	499	4.5	3.5, 5		
Time Spent with Doctor	1, 5	501	4	3, 4		
Accessibility and Convenience	1, 5	500	3.75	3.25, 4.25		
			Mean	**SD**		
Warwick-Edinburgh mental wellbeing scale	14, 70	535	47.4	11.5		
Acceptance of illness scale	8, 40	485	26.1	7.4	None / Moderate / Good	17, 49, 34
Multidimensional health locus of control scale						
Internal	6, 36	486	22.2	5.3		
Chance	6, 36	483	20.3	5.1		
Powerful others	6, 36	484	21.7	5.0		
Big five inventory (BFI-44)						
Extraversion	1, 5	482	3.02	0.77		

Agreeableness	1, 5	482	3.76	0.58		
Conscientiousness	1, 5	479	3.43	0.66		
Neuroticism	1, 5	481	3.12	0.85		
Openness	1, 5	480	3.40	0.56		
Patient activation measure (PAM-13)	0, 100	461	59.3	15.1	Level 1 / 2 / 3 / 4	26, 18, 36, 20
Quality of life scale	16, 112	465	79.8	17.8		

CI - confidence interval; IQR - interquartile range; SD - standard deviation

Total n=625. Data weighted by gender, ethnicity and index of multiple deprivation to be representative of prevalent UK young adults receiving KRT. Where non-parametric, data are presented as median and interquartile range.

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TABLE 3. Regression analyses of psychological health scales in UK young adults receiving kidney replacement therapy by current treatment

Scale	By modality (dialysis v. transplant), adjusted for age and sex			
	β/OR	95% CI		p value
		Lower	Upper	
	OR			
EQ-5D-3L tariff[1]	**0.31**	0.19	0.51	<0.001
General health questionnaire (GHQ-12)[2]	**1.90**	1.22	2.96	0.005
Morisky medication adherence scale (MMAS-8)[3]	**0.40**	0.25	0.64	<0.001
Independence with activities of daily living scale	**0.27**	0.16	0.46	<0.001
Body image scale	**1.74**	1.09	2.76	0.02
Social impact scale	**2.46**	1.57	3.86	<0.001
Multidimensional scale of perceived social support	**0.90**	0.61	1.34	0.61
Patient satisfaction questionnaire (PSQ-18)				
General Satisfaction	**0.55**	0.38	0.80	0.002
Technical Quality	**0.53**	0.33	0.85	0.01
Interpersonal Manner	**0.71**	0.51	1.01	0.06
Communication	**0.58**	0.40	0.84	0.004
Financial aspects	**0.88**	0.54	1.41	0.59
Time Spent with Doctor	**0.39**	0.22	0.68	0.001
Accessibility and Convenience	**0.52**	0.37	0.75	0.001
	β			
Warwick-Edinburgh mental wellbeing scale (WEMWBS)	**-5.61**	-7.92	-3.29	<0.001
Acceptance of illness scale	**-5.35**	-6.78	-3.91	<0.001
Multidimensional health locus of control scale				
Internal	**-1.16**	-2.24	-0.08	0.04
Chance	**0.05**	-1.04	1.13	0.93
Powerful others	**-0.65**	-1.81	0.51	0.29
Big five inventory (BFI-44)				
Extraversion	**-0.09**	-0.27	0.08	0.29
Agreeableness	**-0.11**	-0.21	-0.001	0.05
Conscientiousness	**-0.20**	-0.34	-0.05	0.01
Neuroticism	**0.21**	0.05	0.37	0.01
Openness	**-0.01**	-0.11	0.10	0.90
Patient activation measure (PAM-13)	**-4.52**	-6.94	-2.10	<0.001
Quality of life scale	**-6.79**	-10.7	-2.85	0.001

OR – Odds ratio; CI - confidence interval

Data weighted by gender, ethnicity and index of multiple deprivation to be representative of prevalent UK young adults receiving KRT. Where non-parametric, scale scores are grouped into whether >50th centile or not for logistic regression analyses unless otherwise stated. For parametric data, beta coefficients represent the change in scale units (described in table 2).

1. Grouped in logistic regression analyses as 'No problems/'Some problems' corresponding to a tariff of 1 or <1.
2. Grouped in ordered regression analyses as 'No evidence of probable mental ill health'/'Less than optimal mental health'/'Probable psychological disturbance or mental ill health' corresponding to a scale score of 0, 1 to 3, or 4+.

3. Use of the ©MMAS is protected by US copyright laws. Permission for use is required. A license agreement is available from Morisky Research LLC. The MMAS-8 was grouped in ordered regression analyses as low/medium/high adherence corresponding to a scale score of <6, 6 to 7, or 8.

LEGENDS TO FIGURES

Figure 1. Study flowchart.

Figure 2. Coefficient plot for mutually adjusted factors associated with wellbeing in young adults receiving kidney replacement therapy, measured by the Warwick-Edinburgh Mental Wellbeing Scale.

ADLs – activities of daily living

N=401. Higher scores indicate greater mental wellbeing. The beta coefficient of the model intercept was 57.4 (95% confidence interval 50.9, 63.8), p<0.001. The model adjusted R^2 was 0.68. For personality scales, the coefficient is for each 1-unit scale change. 'Negative body image' is for each 10-unit change on the Body Image Scale. 'Greater social impact' is for each 20-unit change on the Social Impact Scale. Psychological disturbance was defined by a GHQ-12 score of 4 or more. When the GHQ-12 was omitted from the model the adjusted R^2 was 0.62, indicating it does not explain a large proportion of the variance.

Figure 3. Coefficient plot for mutually adjusted factors associated with medication adherence in young adults receiving kidney replacement therapy, measured using the 8-item Morisky Medication Adherence Scale.

N=432. Higher scores indicate a greater degree of medication adherence. The beta coefficient of the model intercept was 3.13 (95% confidence interval (CI) 1.78, 4.48), p<0.001. The model adjusted R^2 was 0.33. For personality and patient satisfaction scales, the coefficient is for each 1-unit scale change. Psychological disturbance was defined by a GHQ-12 score of 4 or more.